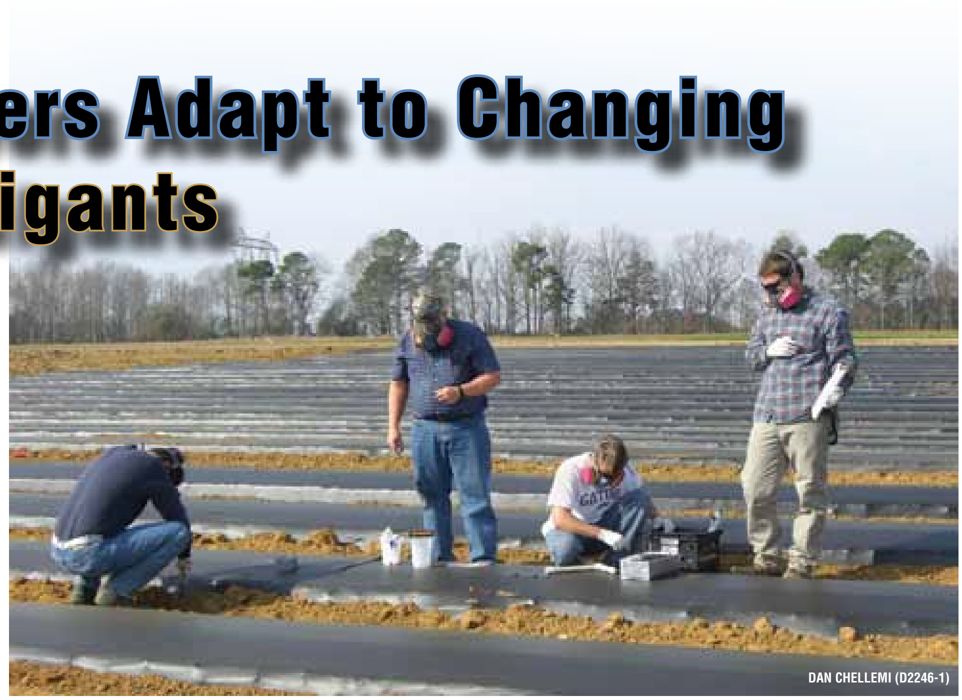
Helping Growers Adapt to Changing Rules on Fumigants



DAN CHELLEMI (D2246-1)

In a fumigated, tarped field in Tifton, Georgia, (left to right) horticulturist Jerry Johnson, plant pathologist Randy Driggers, and technicians Taylor Ivy and Nick Rotindo collect soil and air samples for analysis of chemical fumigants. Samples were collected to evaluate the impact of good agricultural practices on the soil fate and atmospheric emission of chemical fumigants.

For decades, methyl bromide has been an extremely important tool for vegetable, strawberry, deciduous fruit, nursery, and ornamental growers in their efforts to combat soil-dwelling nematodes, diseases, and weeds. But the fumigant is being phased out because of its harmful effects on the Earth's protective stratospheric ozone layer, and alternative fumigants are presenting new challenges for growers and regulatory officials who want to keep the air clean.

The Agricultural Research Service has been conducting research to find the best alternatives to the fumigant since the mid-1990s, and because of the issue's critical importance, the agency initiated a special areawide pest-management project 5 years ago that made several additional research efforts possible. As part of that 5-year effort, ARS researchers in Florida and California are helping to minimize release of the alternative fumigants into the atmosphere with studies focused on fumigant emission rates and the effectiveness of tarps used as barriers to cover fumigated soil. The work also is designed to assist the U.S. Environmental Protection Agency (EPA) and other regulators charged with developing new fumigant requirements to better protect people who use them or live near treated fields.

Under requirements being imposed by EPA, growers who use fumigants will need to establish buffer areas around treated fields to protect neighbors from excessive exposure and develop detailed management plans that include either fumigant monitoring or notifying neighbors of fumigant applications. Experience in California suggests that many growers and pesticide applicators have been able to adapt to these types of fumigant requirements within about a year. But many smaller operations, particularly those near suburbs, may be unable to meet the proposed standards because of their proximity to homes, institutions, and public rights-of way. These include some California strawberry growers and south Florida growers of tomatoes, peppers, and cucumbers, says Dan Chellemi, an ARS plant pathologist at the U.S. Horticultural Research Laboratory in Fort Pierce, Florida.

The financial implications could be significant. In Florida, for instance, tomatoes were a $622 million crop in 2008, and bell peppers were valued at $267 million.

Field studies conducted by Chellemi, Husein A. Ajwa, a former ARS scientist now with the University of California-Davis, and colleagues, showed that implementation of recently developed application equipment and methods reduced emissions to levels far below those found in previous studies. "We found that the differences were quite significant," Chellemi says.

Chellemi and colleagues applied several alternative fumigants under commercial application conditions at three sites near Duette, Florida, and three sites near Tifton, Georgia. The fumigants included chloropicrin, metam sodium, metam potassium,

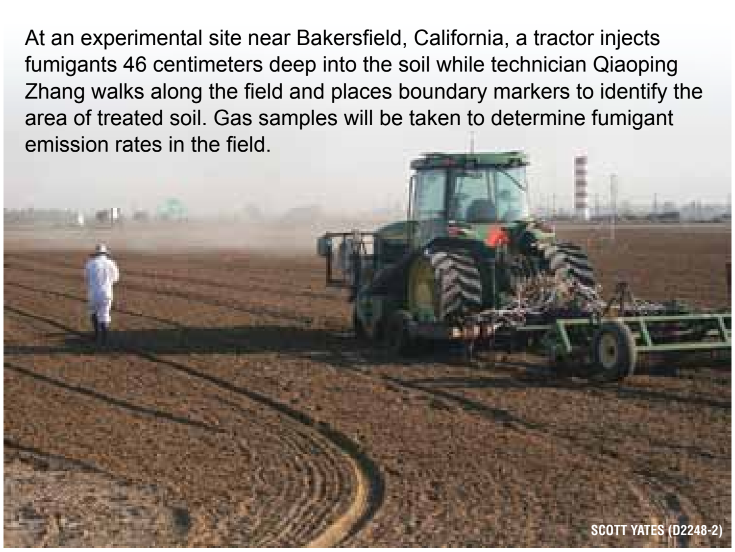
The vertical air-monitoring station located in the center of a fumigated field at a Duette, Florida, site is designed to continuously collect air samples at several heights. Fumigant-collection tubes were exchanged and air-sampling pumps calibrated every 6-12 hours for 10 consecutive days to ascertain fumigant flux rates from soil.

DAN CHELLEMI (D2247-1)

dimethyldisulfide, and 1,3-dichloropropene (sold as Telone). The fumigants were injected into the soil using shanks and low-disturbance coulters mounted on tractors, application methods that are becoming standard practice. The soil was then immediately covered with plastic tarps designed to prevent the fumigant from escaping.

The researchers used different types of plastic tarps, selected sites that included different soil types, and recorded the temperatures and moisture levels of the soil at times when the fumigants were applied. They also set up weather stations to monitor wind speeds and air sampling stations to track emission levels.

They found that emission rates could be drastically affected by the quality of the soil and the type of covering used. Coverings include tarps made with polyethylene or metal and VIF's (virtually impermeable films), which have layers of nylon or other materials imbedded in them. The researchers found that in dry soils with low organic matter content, VIFs worked best at keeping emissions low, while in areas with moisture above field capacity, a more permeable metalized film was equally as effective at reducing emissions. Their studies confirmed that good agricultural practices are critical factors in determining how much fumigant is released into the atmosphere. The EPA has used the results, published in the journal *Atmospheric Environment,* along with results from other recent research, to develop the fumigant standards currently being considered.


At an experimental site near Bakersfield, California, a tractor injects fumigants 46 centimeters deep into the soil while technician Qiaoping Zhang walks along the field and places boundary markers to identify the area of treated soil. Gas samples will be taken to determine fumigant emission rates in the field.

SCOTT YATES (D2248-2)

Testing Film Quality

ARS researcher Sharon Papiernik and her colleagues used specially designed chambers to test the permeability of dozens of films used in field trials to come up with a "resistance factor" that measures each film's ability to serve as a fumigant barrier. Papiernik sandwiched each film between two chambers, injected fumigants into one chamber, and measured both the fumigant that passed through the film into the second (receiving) chamber and fumigant that remained in the source chamber. Because each fumigant had a different chemistry, each behaved differently with each tarp.

The researchers tested 200 film-chemical combinations, including those used in large-scale field trials from the areawide pest management project, and came up with a resistance factor that can be used to determine emission rates for each film and fumigant under a wide range of growing conditions and weather patterns. Papiernik is research leader of the North Central Agricultural Research Laboratory in Brookings, South Dakota.

The results, reported online last year in the *Journal of Environmental Quality,* showed that the VIFs were in fact significantly better barriers to fumigant diffusion than the polyethylene films, but their effectiveness varied depending on the fumigant tested. Some VIFs were less effective under higher humidity levels.

The EPA is developing this approach as the standard testing method for evaluating agricultural plastics used in soil fumigation. The results, along with those from other studies, have provided basic standards for film manufacturers and guidance for growers on which films offer the best options for reducing fumigant emissions.

Math Makes It Simple

A major goal in many fumigant studies is determining the amount of gas released from the soil during the fumigation period. But measuring and calculating emissions is no easy task. It means trying to estimate how much of a fumigant is released in an outdoor environment, where variables range from the chemistry of the fumigant to the temperature and the amount of water vapor in the air.

Such constantly shifting variables make it difficult to determine not only the amount of fumigant being released, but also its effectiveness at killing pests.

Researchers also need to determine how emissions rates are affected by a complicated list of crop-management decisions, such as the permeability of the film being used, the amount of time the film covers the fumigated soil, and the depth of the shank used to inject the treatment into the soil.

Scott Yates, research leader of the Contaminant Fate and Transport Unit at the U.S. Salinity Lab in Riverside, California, took a mathematical approach to the problem and developed a model focused on determining fumigant volatilization rates, the amount of fumigant retained in the soil, the amount released into the air, and the relationship between soil-chemical properties and emissions.

In work published in the *Journal of Environmental Quality,* Yates used the model to calculate fumigant emission rates that compared reasonably well to actual methyl bromide emissions observed in field trials where a polyethylene film was used to cover an 8-acre field. The model can be used to determine how a fumigant will be distributed throughout a field and offers a consistent method for determining emission rates under a wide variety of crop-management scenarios.—By **Dennis O'Brien,** ARS.

This research supports the USDA priority of responding to climate change and is part of Methyl Bromide Alternatives (#308) and Air Quality (#203), two ARS national programs described at www.nps.ars.usda.gov.

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